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H2H HAPA
H4L LECTP
U1S S2196 S2204

(56) Documents Cited

GB 2205010 A	GB 2188799 A	GB 2180706 A
GB 2163614 A	GB 2043371 A	GB 1480745 A
EP 0525962 A2	EP 0193485 A1	WO 90/10998 A1
US 4982424 A		

(58) Field of Search
UK CL (Edition N) G3U UBX , G4H HRCA HRCU , H2H HAPA HSL , H4L LECTP LECTX LECX LERA
INT CL^6 G08B 3/10 , H02H 9/00 9/02 11/00 , H02J 1/04 3/10 4/00 , H04M 1/72 , H04Q 7/18 7/32
Online : WPI

(54) Method and apparatus for limiting peak current levels in electronic equipment

(57) An apparatus for limiting total peak current level includes electronic equipment having independent operational elements 25, 26, 30, 32, 34, a current monitoring element 22, a storage element 24 having pre-stored data relating to current consumption of the independent operational elements; and a controller 18. The controller 18 receives a command from an input element 17 to operate a first operational element in a manner requiring increased current consumption. When the current monitoring element 22 identifies that current consumption in the electronic equipment is at a maximum current level, the controller 18 adjusts the operation of a second operational element to reduce the current consumption of the second operational element. In this manner the total peak current consumption of the electronic equipment is limited. The equipment may be a mobile radio apparatus with a display which is intermittently illuminated by a backlight.

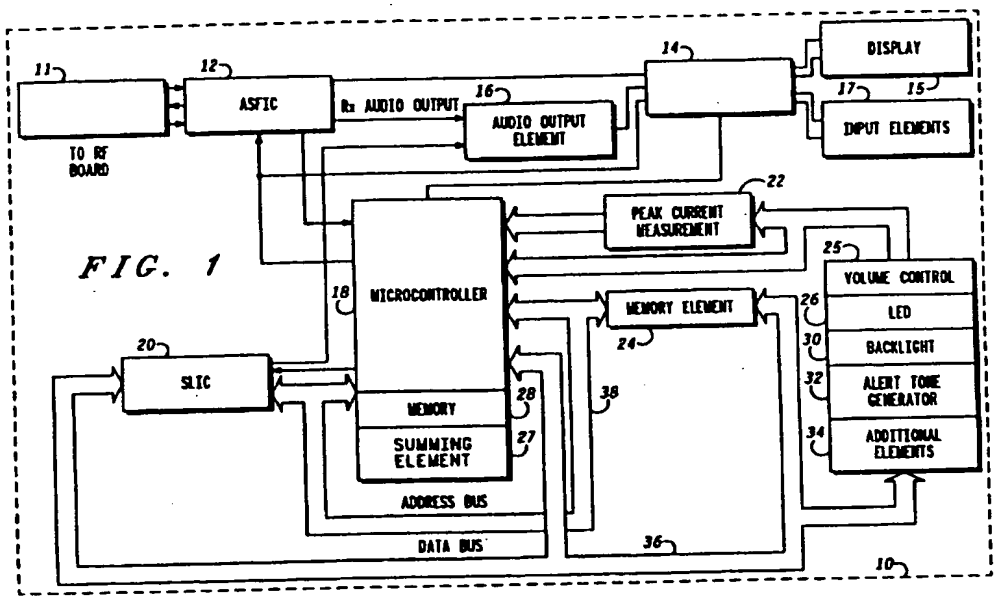


FIG. 1

GB 2 298 499 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

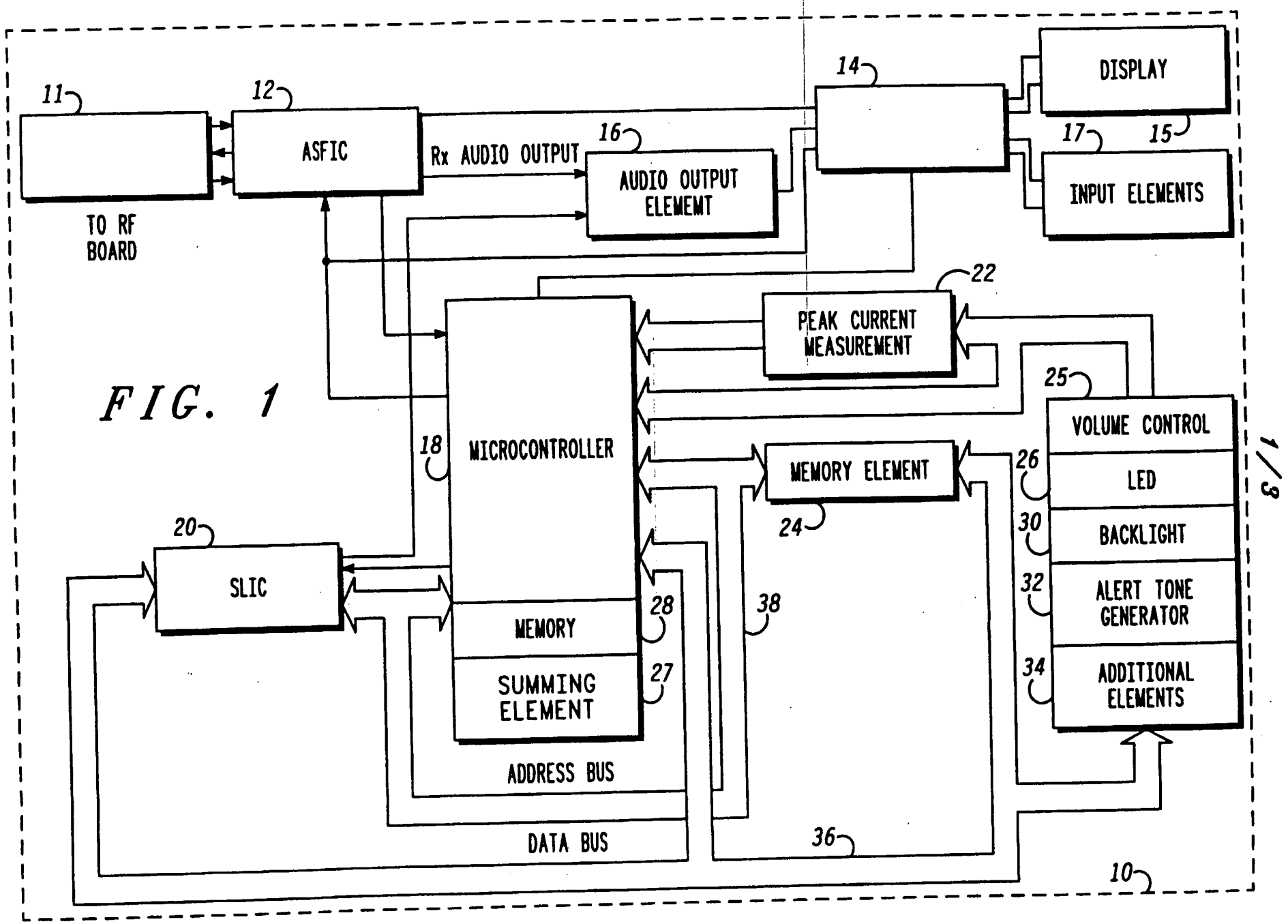
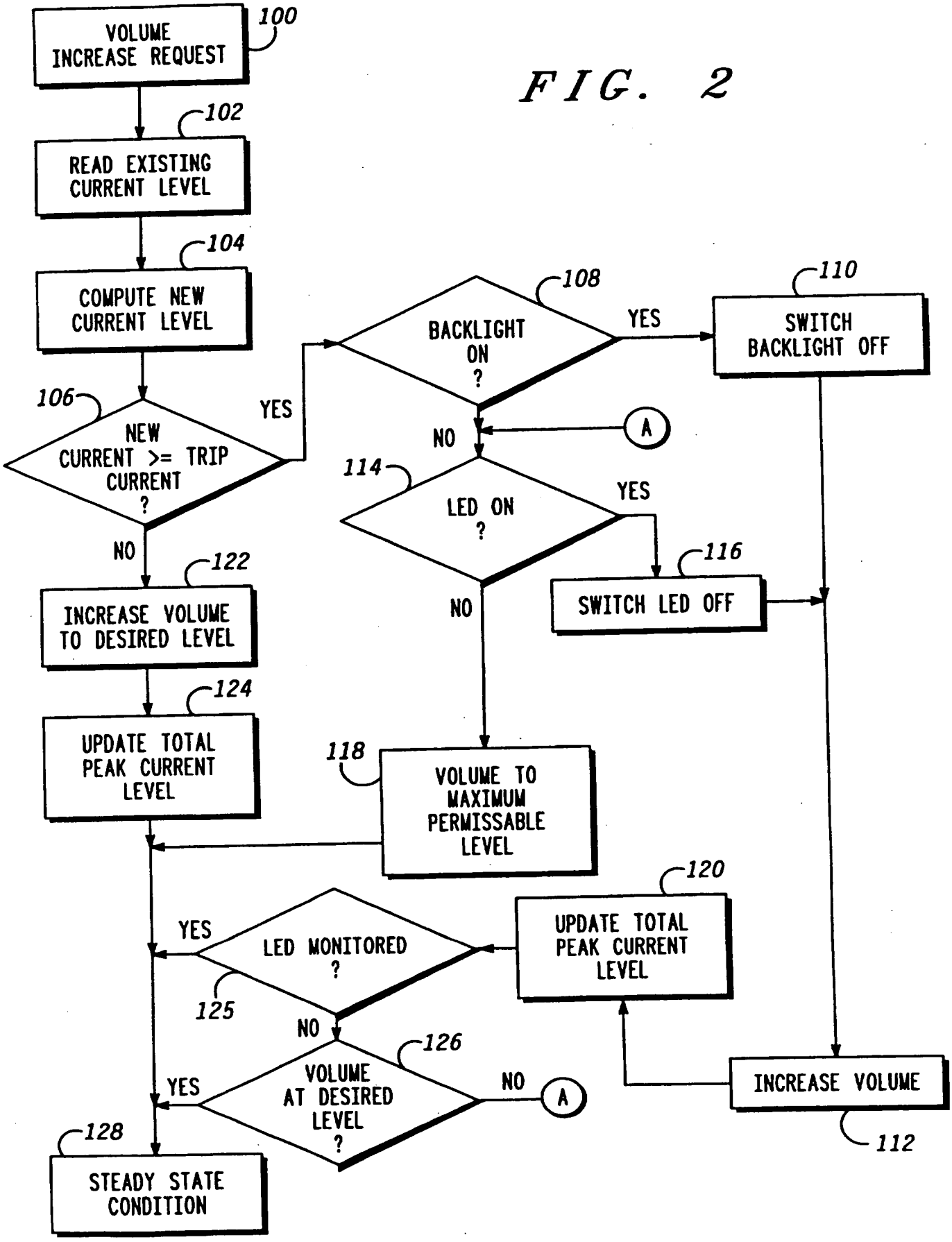

11
12
ASFIC
Rx AUDIO OUTPUT
16
AUDIO OUTPUT ELEMEMT
14
DISPLAY
17
15
INPUT ELEMENTS
TO RF BOARD
22
PEAK CURRENT MEASUREMENT
25
VOLUME CONTROL
18
MICROCONTROLLER
MEMORY ELEMENT
26
LED
24
30
BACKLIGHT
20
SLIC
32
ALERT TONE GENERATOR
28
38
MEMORY
27
34
ADDITIONAL ELEMENTS
SUMMING ELEMENT
ADDRESS BUS
DATA BUS
36
10

FIG. 1

FIG. 2


VOLUME INCREASE REQUEST
100
READ EXISTING CURRENT LEVEL
102
COMPUTE NEW CURRENT LEVEL
104
NEW CURRENT >= TRIP CURRENT ?
106
YES
NO
BACKLIGHT ON ?
108
YES
SWITCH BACKLIGHT OFF
110
A
LED ON ?
114
YES
SWITCH LED OFF
116
NO
INCREASE VOLUME TO DESIRED LEVEL
122
UPDATE TOTAL PEAK CURRENT LEVEL
124
VOLUME TO MAXIMUM PERMISSABLE LEVEL
118
LED MONITORED ?
125
YES
NO
UPDATE TOTAL PEAK CURRENT LEVEL
120
VOLUME AT DESIRED LEVEL ?
126
YES
NO
A
INCREASE VOLUME
112
STEADY STATE CONDITION
128

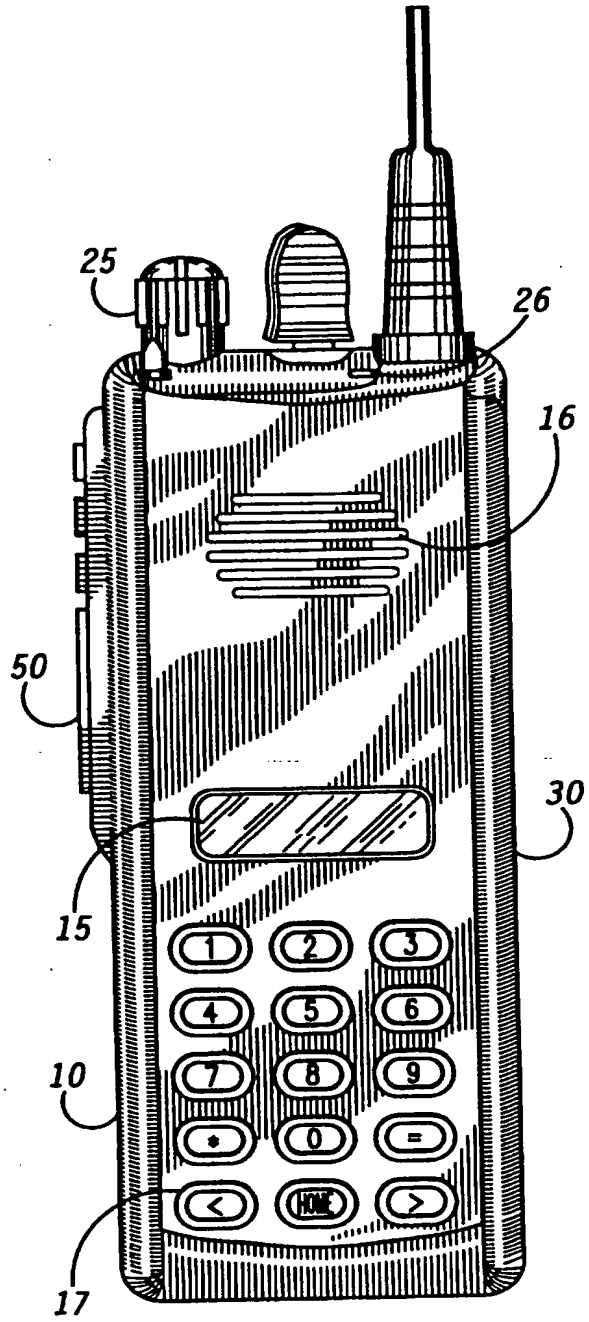


FIG. 3

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METHOD AND APPARATUS FOR LIMITING PEAK CURRENT LEVELS IN ELECTRONIC EQUIPMENT

Field of the Invention

This invention relates to electronic equipment having a plurality of operational elements e.g. volume control, lighting elements such as a backlight or light emitting diodes (LEDs) etc. which require a direct current source. The invention is applicable to, but not limited to, use in mobile radio apparatus. Separately and in addition it relates to a method of operating a radio having a display and a backlight.

Background of the Invention

All items of electronic equipment have electronic circuits that require some form of power supply. Often, the power supply is a direct current (d.c.) power supply and the electronic equipment is required to meet some specification on its operational performance.

In the case of mobile radio equipment, some intrinsically safe mobile radio standards specify a maximum operating temperature for the mobile radio units e.g. IICT4 Cenelec specification. In some operational instances it is necessary to limit the d.c. power, supplied to the mobile radio unit by its internal battery, in order to comply with the standard and meet the maximum operating temperature specification. In such operational instances when the dc power is limited and the total peak current level for the mobile radio unit exceeds a specific peak (trip) current limit, a battery voltage drop occurs. Typically a battery voltage drop in a mobile radio unit causes the microcontroller of the mobile radio unit to be reset. When a microcontroller of a mobile radio unit is reset, the mobile radio unit effectively switches itself off, losing all radio contact and operational functionality. This is undesirable to the mobile radio user.

Thus it is desirable to have electronic equipment arranged to limit the peak current levels of electronic equipment and a method of operation thereof. This invention seeks to mitigate the problem of exceeding peak current levels in electronic equipment and, in particular, peak current levels in mobile radio units.

Summary of the Invention

According to a first aspect of the invention, a method for limiting the total peak current level of electronic equipment having at least first and second independent operational elements is provided. The method comprises the steps of: inputting a command to operate the first operational element in a manner requiring increased current consumption, identifying that the equipment is operating at a maximum current level, and adjusting the operation of at least the second operational element of the electronic equipment to reduce the current consumption of the second operational element.

In a preferred embodiment the method further comprises the electronic equipment having a third independent operational element, and wherein the operation of a selected one of the second and third operational elements is adjusted depending on the required manner of operation of the first operational element. Alternatively, the operation of the first, second and third operational elements are selectively adjusted in a predetermined hierarchical order in response to an input requiring one of the independent operational elements to increase its current consumption. In the preferred embodiment the step of inputting a command to operate the first operational element further comprises inputting of a command to increase the volume control in the electronic equipment and wherein the adjustment of the second operational element is the reduction of the brightness of a display element, such as a light emitting diode (LED) or backlight.

In this manner, the electronic equipment advantageously adjusts the operation of its operational elements to ensure that a specified total peak current level (trip current limit) of the electronic equipment is not exceeded.

According to a second aspect of the invention, a method for limiting the total peak current level of electronic equipment is provided. The method comprises the steps of: obtaining peak current levels of the operational elements in the electronic equipment, summing the peak current levels of the contributing operational elements in the electronic equipment, and adjusting the operation of the operational elements of the electronic equipment to limit the total peak current level of the electronic equipment.

This invention is applicable to any electronic equipment having a plurality of operational elements e.g. volume control, lighting elements such as a backlight or LEDs etc. which require a direct current source. The invention is preferably employed in mobile radio apparatus.

Two methods are proposed for obtaining information on the peak current levels of the operational elements. The peak current levels of the operational elements are pre-programmed into a memory element or alternatively, the peak current levels of the operational elements are continuously measured and the results updated into a memory element.

The peak current levels of the operational elements are subsequently accessed from the memory element, by a microcontroller of the electronic equipment, to determine the optimum operating conditions of the operational elements and ensure the trip current limit for the electronic equipment is not exceeded.

In this manner, the electronic equipment advantageously uses information on the peak current levels of the operational elements of the electronic equipment to adjust the operation of the operational equipment. Thereby, operating the electronic equipment within the desired total peak current level of the electronic equipment ensuring that a specified trip current limit is not exceeded.

According to a third aspect of the invention, electronic equipment is provided comprising at least first and second independent operational elements. The electronic equipment further comprises a current monitoring element for monitoring current consumption in the electronic equipment and a storage element having pre-stored data relating to current consumption of at least the first and second independent operational elements. The electronic equipment further comprises an input device for inputting operational commands and a controller coupled to the first and second operational elements, the current monitoring element, the storage element and the input device via the display interface. The controller receives from the input device a command to operate the first operational element in a manner requiring increased current consumption and adjusts operation of at least the second operational element to reduce the current consumption of the second operational element. The controller performs this operation when the current monitoring element identifies that current consumption in the electronic equipment is at a maximum current level.

Advantageously a means for limiting the total peak current consumption of the electronic equipment is provided.

According to a fourth aspect of the invention, there is provided a method of operating a radio having a display and a backlight for illuminating the display, comprising: generating an alert signal and intermittently illuminating the display.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the drawings.

Brief Description of the Drawings

FIG. 1 shows a schematic block diagram of a mobile radio unit in accordance with the preferred embodiment of the invention.

FIG. 2 shows a method of limiting the total peak current level of the operational elements in a mobile radio unit in accordance with the preferred embodiment of the invention.

FIG. 3 is an illustration of the front of a portable radio in accordance with a further preferred embodiment of the invention.

Detailed Description of the Drawings

In the preferred embodiment of the invention, electronic equipment is shown as a mobile radio unit 10. Referring first to FIG. 1, a schematic block diagram of the operation of a microcontroller 18 in the mobile radio unit 10 is shown. An audio signalling filter integrated circuit (ASFIC) 12 is connected to a radio frequency interface unit 11, an audio output element 16, an accessory and display interface 14 and the microcontroller 18. The display interface 14 is connected to a display 15 and input elements 17, such as a keypad, channel switch, up/down volume buttons. The microcontroller 18 contains a first memory element 28, a summation element 27 and has both data bus 36 and address bus 38 connections to both a support logic integrated circuit (SLIC) 20 and a second memory element 24. The microcontroller 18, SLIC 20 and second memory element 24 are all connected via the data bus 36 to operational elements. The operational elements include a light emitting diode (LED) 26, a volume control element 25, a backlight 30, an alert-tone generator 32 and additional operational elements 34.

In operation, the timing for the microcontroller 18 is generated by the ASFIC 12. The microcontroller 18, in conjunction with the SLIC 20, has two basic functions: firstly, to interface to other parts of the mobile radio unit 10 and secondly, to control the internal workings of the mobile radio unit 10.

An example of the current limiting operation of the microcontroller 18 with the SLIC 20 is in the case of the microcontroller 18 receiving a request from an input element 17 to operate a first

operational element e.g. volume control 25, in a manner requiring increased current consumption. The microcontroller 18 identifies that the mobile radio 10 is operating at a maximum current level and therefore adjusts the operation of a second operational element e.g. a display element such as a backlight 30, of the mobile radio 10 to reduce the current consumption of the second operational element. In this manner, and advantageously, the total peak current level of the mobile radio 10 is limited. This example can be extended to include additional operational elements whereby the microcontroller 18 determines which of the operational elements are to be adjusted to reduce the total current consumption of the mobile radio 10. The operational elements can be selectively adjusted in a predetermined hierarchical order in response to a request to operate one of the operational elements of the mobile radio 10 in a manner requiring increased current consumption.

In the preferred embodiment, the microcontroller 18 and SLIC 20 constantly monitor and control the operation of the operational elements and interpret any changes in the peak current levels into commands that control the operation of the mobile radio unit 10. An example of the peak current levels (in mA), stored in the second memory element 24 for the operational elements, is shown in Table 1.

Operational element	Status	Direct Current (mA)
Backlight	"on"	60
LED	"off"	15
Audio power amplifier	"on"	Dependent upon level
Alert-tone	"off"	—
Total	—	75 + volume control

Table 1

The peak current levels of the operational elements are stored in the second memory element 24. The total peak current level of the mobile radio unit 10 is obtained by summing the peak current levels of the contributing operational elements in the summation element 27 of the microcontroller 18.

Advantageously, the microcontroller 18, together with the SLIC 20, controls the total peak current level of the mobile radio unit 10 and ensures that it does not exceed a specific trip current limit, thereby avoiding any resetting of the microcontroller 18.

Operations and operating conditions within the mobile radio unit 10 are interpreted by the microcontroller 18 and fed back to the mobile radio user as visible (by the display) or audible (alert-tone) indications of the present status of the mobile radio unit 10. The SLIC 20 provides extra input/output ports. These ports are used to generate additional control signals or to receive peak current levels from additional operational elements 34. In addition, the SLIC 20 provides a memory management function.

Referring now to FIG. 2, a flow chart describing an example method of limiting the peak current level of a mobile radio unit 10, according to the preferred embodiment of the invention, is shown. The microcontroller 18 receives a request to increase the volume via the volume control operational element 25, as shown in step 100. The peak current levels for the operational elements are measured, as in step 102. The summation element 27 of the microcontroller 18 computes the total peak current level, as in step 104. The total peak current level is then compared to the trip current limit for the mobile radio unit 10, as shown in step 106. If the total peak current level, required to perform the volume increase is greater than the trip current limit, the backlight 30 is monitored to see if it is switched "on", as shown in 108. If the backlight 30 is found to be "on", the backlight 30 is switched "off" to reduce the total peak current level, as in step 110. The volume level is then increased via the volume control element 25, as in step 112, to either the desired volume level or a volume level where the total peak current level is just less than the trip current limit. The total peak current level is updated in the second memory element 24, as shown in step 120.

If the LED 26 has already been monitored for peak current limiting purposes, as shown in step 125, the mobile radio unit 10 returns to a steady state condition in step 128. If the LED 26 has not been monitored, the existing volume level is compared with the desired volume level, as in step 126. If the increased volume level has reached the desired volume level, as in step 126 the mobile radio unit 10 returns to a steady state condition, as shown in step 128. If the increased volume level has not reached the desired volume level, as in step 126, or the backlight is switched "off", as in step 108, the microcontroller 18

monitors whether the LED 26 is switched "on", as shown in step 114. If the LED 26 is found to be "on", the LED 26 is switched "off", as in step 116. The volume level is then increased via the volume control element 25, as in step 112, to either the desired volume level or a volume level where the total peak current level is just less than the trip current limit. The total peak current level is updated in the second memory element 24, as shown in step 120. In this situation the LED 26, in step 125, has already been monitored and the mobile radio unit 10 returns to a steady state condition, as in step 128. If the LED 26, in step 114, is found not to be "on", the volume level is increased via the volume control element 25 to a volume level where the total peak current level is just less than the trip current limit, as shown in step 118. The mobile radio unit 10 is then returned to a steady state condition, as in step 128.

If the desired volume level will not cause the trip current limit to be exceeded, as in step 106, the volume level is increased to the desired volume level, as in step 122, and the total peak current level is updated in the second memory element 24, as in step 124. The mobile radio unit 10 is then returned to a steady state condition, as shown in step 128.

It is within the scope of the invention that additional operational elements 34 may also be switched "off" or switched into a reduced current mode of operation. In such situations, step 118 would be extended to include monitoring the operational status of these additional operational elements 34. A similar process to that previously described would then be implemented. It is also within the scope of the invention that the microcontroller 18 monitors the peak current levels of the operational elements in whichever order is most applicable to the operation of the mobile radio unit 10.

Thus a method has been provided to ensure the total peak current level of a mobile radio unit 10 does not exceed a specific trip current limit.

FIG. 3 is an exterior front view of a particularly preferred embodiment of the invention.

As well as the display 15, with its backlight 30, the audio output element 16 (a loudspeaker), the input elements (keypad) 17, the volume control element 25 and the LED 26, there is shown a push-to-talk (PTT) button 50. It is also shown that the backlight 30 illuminates the display 15. Advantageously, though not essentially, the backlight 30 also illuminates the keypad 17. Instead of mounting the display on the front

of the radio as shown, it may be mounted on the top, beside the volume control element 25.

In operation, the backlight 30 is switched off when the loudspeaker 16 is open. This happens, for example, when an incoming signal causes a squelch circuit (not shown) to open.

Operation is according to the following truth table:

Carrier	LED	Loudspeaker Open
YES	OFF	YES
YES	FLASHING	NO
NO	OFF	NO

Table 2

If there is incoming carrier but no audio (squelch is not opened), and the loudspeaker 16 is not open, the LED 26 illuminates intermittently.

If there is incoming modulated carrier, the loudspeaker is open and the LED 26 is off.

If the PTT button 50 is pressed, this opens a transmitter circuit (not shown) and the backlight 30 is switched off, again to minimise current.

In this embodiment, peak current measurement is not necessary. The truth table dictates the operation exclusively.

If there is an incoming alert signal, an audio tone is output by the audio output element 16. This tone is intermittent. With each occurrence of the tone, the backlight 30 is switched off. This has the very advantageous feature of creating a visually distinctive alert signal. The entire display 15 and keypad 17 flashes, with no increase in peak current.

Claims

1. A method of limiting a total peak current level in electronic equipment having at least first and second independent operational elements, comprising the steps of:

inputting a command to operate the first operational element in a manner requiring increased current consumption;

identifying that the equipment is operating at a maximum current level;

adjusting operation of at least the second operational element of the electronic equipment to reduce current consumption by the second operational element, thereby limiting the total peak current level of the electronic equipment.

2. A method according to claim 1 of operating electronic equipment having at least first, second and third independent operational elements, wherein the operation of a selected one of the second and third operational elements is adjusted depending on the required manner of operation of the first operational element.

3. A method according to claim 1 of operating electronic equipment having at least first, second and third independent operational elements, wherein the operation of the first, second and third operational elements is selectively adjusted in a predetermined hierarchical order in response to inputting a command to operate one of said elements in a manner requiring increased current consumption.

4. A method according to claim 1, wherein the step of inputting a command to operate the first operational element further comprises inputting of a command to increase audio volume in an audio output element and

wherein the adjustment of the second operational element further comprises reducing brightness of a display element.

5. A method of limiting the total peak current level in electronic equipment comprising the steps of:

obtaining peak current levels of operational elements in the electronic equipment,

summing peak current levels of contributing operational elements in the electronic equipment, and

adjusting operation of the operational elements of the electronic equipment to limit the total peak current level of the electronic equipment.

6. The method of claim 5 wherein the electronic equipment is a mobile radio unit.

7. The method of either of claims 5 or 6 wherein a microcontroller adjusts the operation of the operational elements.

8. The method of any one of claims 5 to 7 wherein the operational elements include at least one of the following: volume control, backlight, light emitting diode, alert-tone generator.

9. The method of any one of claims 5 to 8 wherein the peak current levels of the operational elements are pre-programmed into a memory element and subsequently accessed by the microcontroller.

10. The method of any one of claims 5 to 9 wherein the peak current levels of the operational elements are continuously measured and the results updated into a memory element, subsequently accessed by the microcontroller.

11. Electronic equipment comprising:

at least first and second independent operational elements (25, 26, 30, 32, 34);

a current monitoring element (22) for monitoring current consumption in the equipment, including current consumption in active ones of the first and second independent operational elements;

a storage element (24) having pre-stored data relating to current consumption of the first and second independent operational elements;

a controller (18) coupled to the first and second operational elements, the current monitoring element, the storage element and a display interface, operably coupled to a display (15) and an input element (17) for receiving from the input element (17) a command to operate the first operational element in a manner requiring increased current consumption and for adjusting operation of at least the second operational element to reduce current consumption by the second operational element when the current monitoring element (22) identifies that current consumption in the electronic equipment is at a maximum current level, thereby limiting the total peak current consumption of the electronic equipment.

12. A method of operating a radio having a display and a backlight for illuminating the display, comprising:

generating an alert signal and

intermittently illuminating the display.

'atents Act'1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9503989.7

Relevant Technical Fields

(i) UK Cl (Ed.N) G3U (UBX); G4H (HRCA); H2H (HAPA, HSL); H4L (LECTP, LECTX, LECX)

(ii) Int Cl (Ed.6) H02H (9/00, 9/02, 11/00); H02J (1/04, 3/10, 4/00); H04Q (7/32); H04M (1/72)

Search Examiner
D C BRUNT

Date of completion of Search
19 MAY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-11

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,Y	GB 2205010 A	(GEWERKSCHAFT EISENHUTTE) see page 10 line 23 - page 12 line 6	X:1-3, 5, 7 Y:6
X,Y	GB 2188799 A	(BERTENSHAW) whole document	X:1-3, 5, 7 Y:6
X,Y	GB 2180706 A	(SANDEN) see page 1 lines 27-32	X:1, 5 Y:6
Y	GB 2163614 A	(PHILIPS) see page 1 lines 5-46	6
X,Y	GB 2043371 A	(S E ELECTRICITY) whole document	X:1-3, 5, 7 Y:6
X,Y	GB 1480745	(RCA) whole document	X:1, 2, 5, 8 Y:6
Y	EP 0525962 A2	(TECHNOPHONE) see page 2 line 55 - page 3 line 2	6
X,Y	EP 0193485 A1	(UNITED TECHNOLOGIES) see page 3 line 20 - page 6 line 6	X:1-3, 5, 7 Y:6

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journ (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

'atents Act 1977 2ND SEARCH
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9503989.7

Relevant Technical Fields

(i) UK Cl (Ed.N) G4H (HRCU); H4L (LECX, LERA)

(ii) Int Cl (Ed.6) G08B (3/10); H04M (1/72); H04Q (7/18, 7/32)

Search Examiner
D C BRUNT

Date of completion of Search
19 MAY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE: WPI

Documents considered relevant following a search in respect of Claims :-
12

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	WO 90/10998 A1	(MOTOROLA) see page 2 lines 27-32 and page 12 lines 23-26	12
X	US 4982424	(SAITO) see column 3 lines 42-47	12

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).